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VERIFICATION OF TRANSLATION

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Edmund BERGER, residing at 298 Grayton Road, Tonawanda, NY 14150,

declares:

- (1) that he knows both the German and English languages well;
- (2) that he translated the German document entitled "Measuring Device with a Hall Sensor and Method for Fabricating Said Measuring Device" from German to English;
- (3) that the attached English Translation is a true and correct translation of the above-identified German document to the best of his knowledge and belief;  
and
- (4) that all statements made of his knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

Dated: November 4, 2004

Signed:

  
S. Edmund BERGER

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**Measuring Device with a Hall Sensor and  
Method for Fabricating Said Measuring Device**

**Description**

**Technical Field**

The invention relates to a measuring device with a Hall sensor, particularly for displacement measurement, and to a method for fabricating said measuring device.

**Prior Art**

It is known to use Hall sensors for measuring various parameters. Such sensors are used, for example, for measuring magnetic fields, wattage in high-voltage power lines, for contactless control and regulation of motion and many others. The measurement of motion, however, is possible only for very short motion paths of only a few millimeters.

**Presentation of the Invention**

The object of the invention is to provide a measuring device with a Hall sensor to be used, in particular, for displacement measurement and whereby longer paths than before can also be measured with accuracy.

Another object is to provide a method for fabricating said measuring device.

According to the invention, in a measuring device with a Hall sensor, particularly for displacement measurement, this objective is reached by disposing the Hall sensor in a magnetic tube centrally and so that it can be moved axially, each half of said magnetic tube being cross-magnetized with opposite polarity. Tests have shown that such a measuring device provides very accurate measurements over a considerably longer path length than previous measuring devices with Hall sensors. For example, with a magnetic tube length of 20 mm, an approximately linear range useful for the measurement and having a length of about 14 mm was achieved.

In designing the measuring device, it is important that the Hall sensor be kept in an axially displaceable support, or that it can be displaced axially in a support in a manner such that rotary motions of the Hall sensor relative to the magnetic tube are not possible.

The novel Hall sensor is of simple configuration and is suitable for measurements over long paths. It is not subject to disturbances and is virtually linear. Moreover, it does not require external electronic evaluation circuits. The Hall sensor is moved centrally in the magnetic tube, each half of said tube being cross-magnetized with opposite polarity. The flux density is highest at a distance of a few millimeters from the poles. In the center of the magnetic tube, said flux density is nil and changes its direction.

Compensation of the temperature dependence can be achieved in simple manner by suitably pairing the Hall sensor with the material of which the magnet is made so that the temperature variations of the two materials will compensate each other.

The fabrication of Hall sensors is in itself known. Different methods can be used to produce the novel magnetic tube for the measuring device. An advantageous method consists of cross-magnetizing a tube made of magnetizable material in a diametrically opposite manner so that in the upper part of the tube one half of the tube is magnetized as the magnetic north pole and the other half of the tube as the magnetic south pole. In the bottom part of the tube, the procedure is reversed, namely one half of the tube is magnetized as the magnetic south pole and the other half as the magnetic north pole.

A very simple method for fabricating the magnetic tube for the measuring device consists of through-magnetizing a tube of magnetizable material perpendicularly to its axis so that one half of the tube is magnetized as the magnetic north pole and the other half of the tube as the magnetic south pole. The tube is then severed across its axis, and one of the parts of the tube is turned 180° relative to the other part of the tube. In this manner are obtained the diametrically opposite north and south poles of the magnetic tube for the measuring device.

### **Brief Description of the Drawings**

The invention will now be explained in greater detail with the aid of the practical examples represented in the drawings, in which

Fig. 1 and Fig. 2 show a top view and a longitudinal sectional view of the configuration principle of the measuring device.

Fig. 3 shows a diagram of a measuring signal recorded in gauss against the measuring path.

Fig. 4 shows the procedure for diametrically opposite through-magnetization, and

Fig. 5 shows the use of the measuring device in a pneumatic adjustment unit.

### **Execution of the Invention**

Fig. 1 shows the configuration principle of measuring device 1, said measuring device consisting of magnetic tube 2 with north pole side 3 and south pole side 4, as well as the Hall sensor 5 disposed centrally in magnetic tube 2.

As can be seen from Fig. 2, magnetic tube 2 is configured so that, seen in longitudinal direction, it is divided into two halves, namely one half 6 with the north pole on the left side and the south pole 4 on the right side, the other part, the other half 7 of magnetic tube 2, being disposed in reverse manner, namely north pole 3 is located on the right side and south pole 4 on the left side of magnetic tube 2. As indicated by double arrow 8, in the magnetic tube, Hall sensor 5 can be moved back and forth in the axial direction. For this purpose, there is provided a support, not shown in detail, which permits axial movement of Hall sensor 5, but prevents said Hall sensor 5 from rotating relative to magnetic tube 2.

Fig. 3 shows the diagram of a performed test in gauss against the path length. For a measuring device with a magnetic tube of 20-mm length, a usable, nearly linear range of about 14 mm was obtained. Measuring line 10 was obtained by use of Hall sensor 5 disposed in the middle of magnetic tube 2, whereas measuring line 20 was obtained with a Hall sensor 5 disposed in the vicinity of the inner wall of magnetic tube 2. The outer diameter of the magnetic tube was 14 mm and the inner diameter of the magnetic tube was 8 mm. For both measuring lines 10 and 20, range 15 is approximately linear and may be viewed as useful.

Fig. 4 shows a side view of the magnetic tube 2 used for the measurements. The height of the tube was  $H = 24$  mm, the inner diameter  $DE = 8$  mm, and the outer diameter  $DA = 14$  mm. The upper half 6 of tube 2 shown in the drawing was through-magnetized from left to right as indicated by arrow 11, whereas the lower half 7 of magnetic tube 2 was through-magnetized in the opposite direction as indicated by arrow 12. This diametrically opposite through-magnetization of magnetic tube 2 afforded the arrangement of magnetic poles 3 and 4 shown in Fig. 2.

Fig. 5 shows a practical example of the application of the novel measuring device 1. Measuring device 1 is disposed centrally in a vacuum adjustment unit used in the motor vehicle field. The configuration of magnetic tube 2 is that of the magnetic tube represented in Figs. 1 and 2. Hall sensor 5 is disposed centrally in the middle of magnetic tube 2. The entire measuring device 1 is disposed within vacuum chamber 31 of adjusting unit 30. By means of measuring device 1, the position of support 32 relative to its zero position can be measured and transmitted to the electronic system of the engine.